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METHANE DESORPTION IN COAL HANDLING

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METHANE DESORPTION IN COAL HANDLING

by

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ABSTRACT

The problem of methane in coal results from three distinct processes: methane formation, methane retention in geological time and methane desorption in mining/handling of coals.

The formation of methane in coal is due to its rank metamorphism where the amount depends on coal rank and maceral composition. Of the three maceral groups the inertinites form the least amount of methane. Further the vitrinites form more methane than the exinites until the rank of "coalification break" is reached after which the trend is reversed. The retention of methane in a coal seam depends, above all, on the amount of methane formed and then on the permeability of the surrounding rock.

The desorption of methane depends on the rank and maceral composition of the coal substance, its hardness and brittleness, pore volume pore surface and microfissures. These factors are all inherent characteristics of coals. The desorption depends also on several operational factors: degree of coal fragmentation, stress, temperature, pressure, etc.

The desorption in open air is not a problem but in a closed space, for example, underground mine, storage silo, preparation plant, cargo ship in transit etc., this can be serious.

The methane desorption characteristics in coal handling in all such areas have been discussed with a view to reducing the hazards associated with methane desorption. Also the importance of the direct desorption test method and microhardness technique in determining desorption characteristics has been discussed.

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DÉSORPTION DU MÉTHANE PENDANT LA MANUTENTION DU CHARBON

par

B. Das*

RÉSUMÉ

Le problème du méthane dans le charbon découle de trois procédés différents : la formation de méthane, la rétention de méthane au cours des temps géologiques et la désorption du méthane pendant l'extraction et la manutention du charbon.

La formation de méthane dans le charbon est causée par la transformation métamorphique de son rang qui dépend du rang et de la composition macérale du charbon. Des trois groupes macéraux, les inertinites sont celles qui produisent le moins de méthane. Par ailleurs, les vitrinites donnent lieu à la formation de plus de méthane que les exinites et ce, jusqu'à ce que le "point de houillification" soit atteint, après quoi, la tendance est renversée. La rétention de méthane dans un gîte de charbon dépend, avant tout, de la qualité du méthane en formation et ensuite, de la perméabilité de la roche avoisinante.

La désorption du méthane dépend du rang et de la composition macérale du charbon, de sa dureté et friabilité, du volume et de la surface de ses pores ainsi que des microfissures présentes. Ces éléments sont tous des caractéristiques inhérentes du charbon. La désorption dépend également de plusieurs éléments reliés à l'exploitation tels, le degré de fragmentation du charbon, les contraintes, la température, la pression, etc.

La désorption du méthane en plein air ne constitue pas un problème. Cependant, dans une espace fermé, comme par exemple, une mine souterraine, un réservoir de stockage, une installation de préparation ou un cargo en transit, le problème peut prendre une ampleur considérable.

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INTRODUCTORY NOTE

Methane is associated with all types of coals and thus creates problems through desorption in coal handling: mining, storage, transportation, preparation and utilization. Although the total amount of methane desorption is important, the degree of methane hazards is directly related to the rate of desorption.

The problem of methane in coal handling can be viewed as the resultant effects of the process of formation, retention and desorption of methane. The above processes in turn depend on the following factors: coal rank, maceral composition, type of metamorphism, temperature, pressure, etc.

Methane hazards can be drastically reduced through a clear understanding of these processes.

This report puts together the slides presented to the Annual Meeting of the Calgary CIM on the above subject.

SLIDE PRESENTATION

1 - 30

DISCUSSED HERE ARE:

* DESORPTION SITES IN COAL HANDLING
* FORMATION/RETENTION OF METHANE
* DESORPTION OF METHANE
    * DESORPTION FACTORS
    * DESORPTION CHARACTERISTICS
    * SIMPLE PREDICTION METHODS

DESORPTION SITES

HAZARDOUS SITES
(CLOSED SPACE)

* UNDERGROUND MINES/EXCAVATIONS
* STORAGE SILOS
* PREPARATION PLANTS
* COAL SHIPS

SAFER SITES
(OPEN SPACE)

* SURFACE MINES
* OPEN STACKS
* OPEN COAL TRUCKS/CARS

FORMATION OF METHANE IN COAL IS DUE TO RANK METAMORPHISM

* ITS AMOUNT DEPENDS ON:
  * RANK
  * MACERAL COMPOSITION
  * MODE OF RANK IMPROVEMENT
    * NORMAL
    * ABNORMAL

RETENTION OF METHANE DEPENDS ON:

* AMOUNT OF METHANE FORMED
* PERMEABILITY OF THE SURROUNDINGS
* PORE VOLUME OF COAL
* INTERNAL SURFACE OF COAL

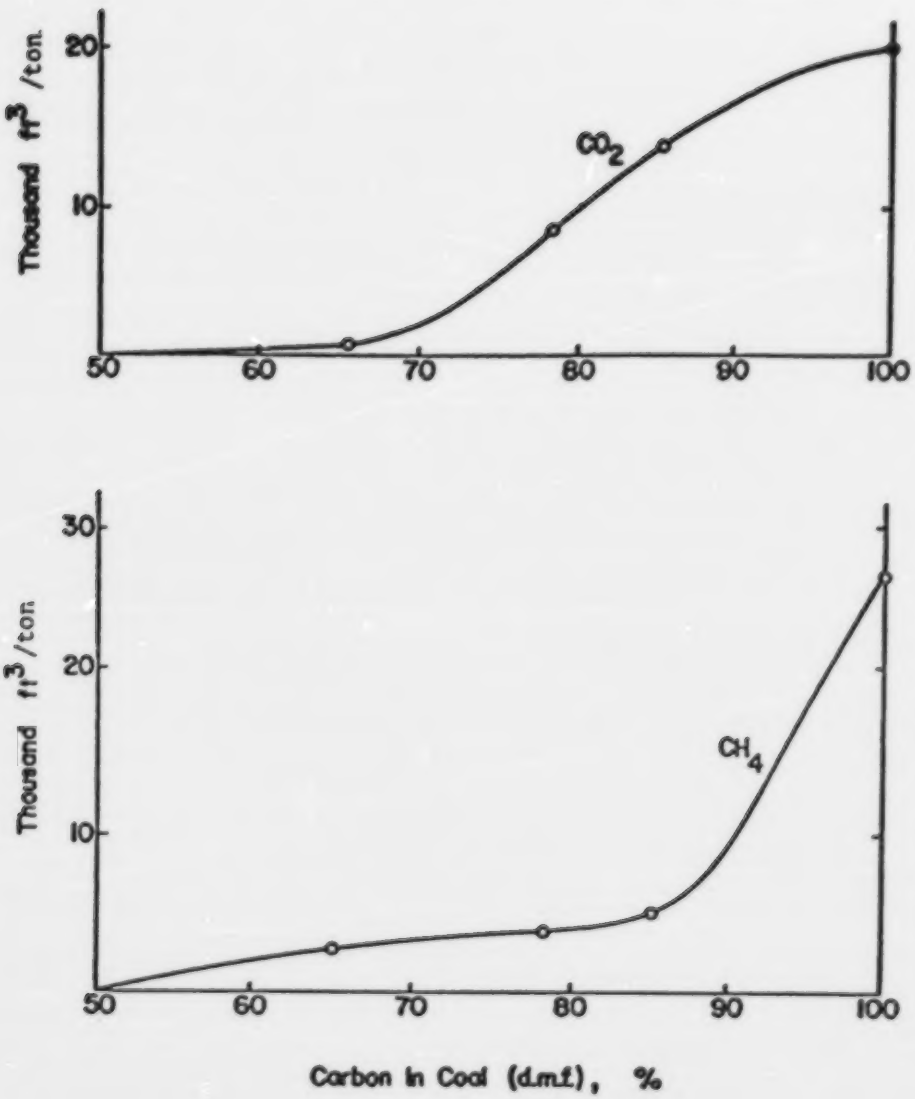

Fig. 1 Release of total gas at different stages of coalification. (1)

THE PRINCIPAL MACERAL GROUPS

* VITRINITIES (HUMINITES)
  * COLLINITE
  * TELINITE

METHANE PRODUCTION - INTERMEDIATE

* EXINITES (LIPTINITES)
  * SPORINITE
  * CUTINITE
  * ALGINITE
  * RESINITE
  * SUBERINITE

METHANE PRODUCTION - MAXIMUM

* INERTINITES
  * MICRTINITE
  * FUSINITE
  * SEMIFUSINITE
  * SCLEROTINITE
  * FUNGINITE

METHANE PRODUCTION - MINIMUM

COALIFICATION BREAK

* THIS TAKES PLACE AT ABOUT 87% C OR 29% V.M. (d.m.f) - BOUNDARY BETWEEN HIGH VOLATILE AND MEDIUM VOLATILE BITUMINOUS COALS

* SPORINITES CAN NOT BE DISTINGUISHED FROM VITRINITES UNDER A MICROSCOPE

* DRASTIC DROP IN HYDROGEN CONTENT OF EXINITES AFTER THE COALIFICATION BREAK AND THERE IS A REVERSAL IN THE HYDROGEN CONTENT COMPARED TO VITRINITES

* AT THIS STAGE EXINITES CONTRIBUTE STRONGLY TO THE FORMATION OF METHANE BUT AT HIGHER RANK EXINITES' ROLE IS REDUCED

RANK METAMORPHISM

* NORMAL (REGIONAL):
  LOW TEMPERATURE/LONG DURATION

* ABNORMAL (CONTACT):
  HIGH TEMPERATURE/SHORT DURATION

MORE GAS IN RELATION TO RANK IS GENERALLY PRODUCED IN ABNORMAL METAMORPHISM THAN IN NORMAL METAMORPHISM. HOWEVER THE PROPORTION OF METHANE WILL VARY DEPENDING ON THERMODYNAMIC CONDITIONS.

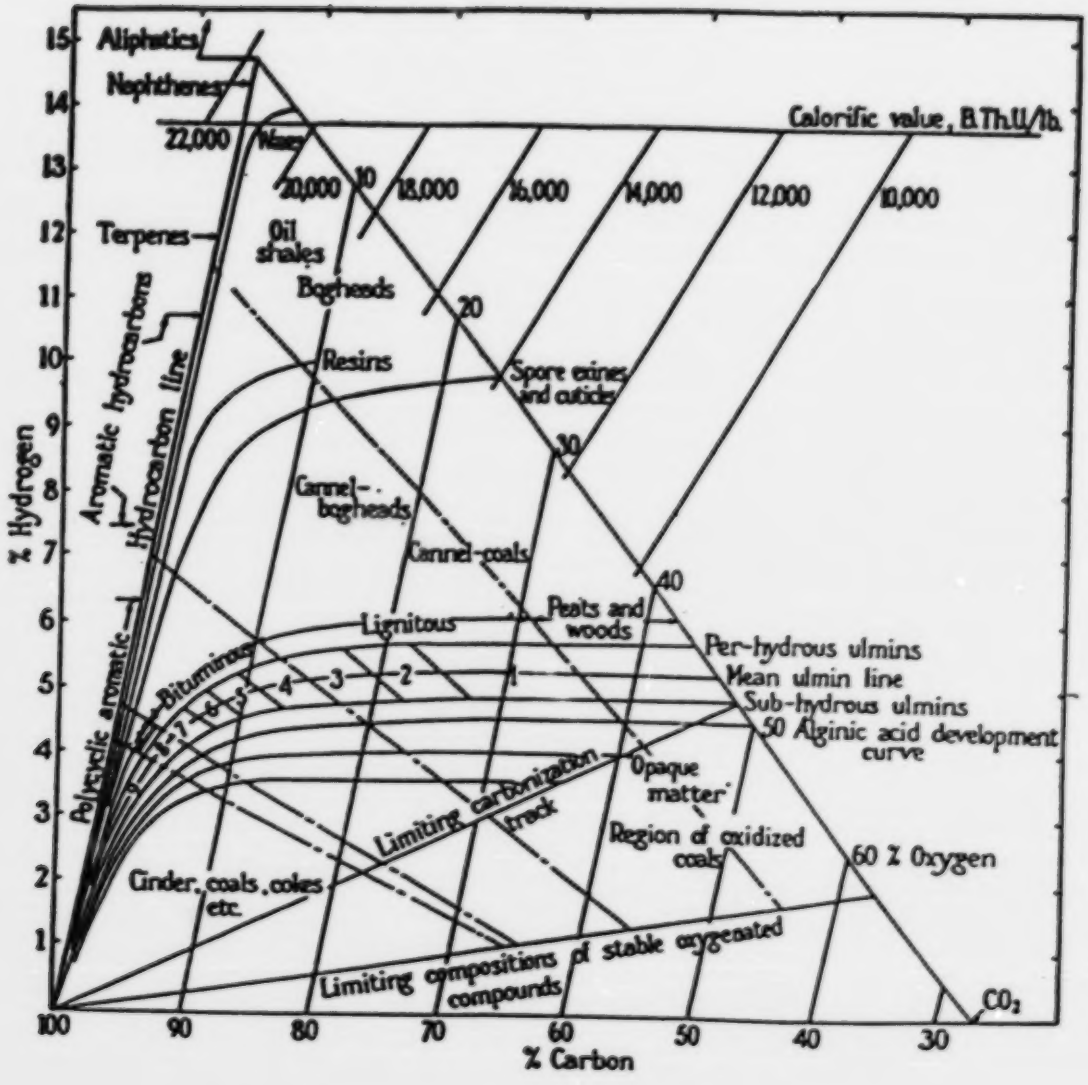

Fig. 2 Basic Rational Classification Chart. (2).

METHANE RETENTION

* IT EXISTS IN COAL/ROCK
  * MAINLY IN THE ADSORBED STATE ONTO THE COAL SURFACES
  * FILLING THE PORES AND FRACTURES OF THE COAL MASS
  * FILLING THE SPACE OF POROUS ROCK STRATA

* RETENTION AMOUNT
  * HIGH FOR HIGH RANK COALS AND SANDSTONE ROOFS
  * LIGNITES/SUB-BITUMINOUS COALS HAVE GREATER PORE VOLUME/SURFACE BUT VERY LITTLE METHANE IS FORMED AT THAT STAGE. ALSO GREATER OPPORTUNITY TO ESCAPE.

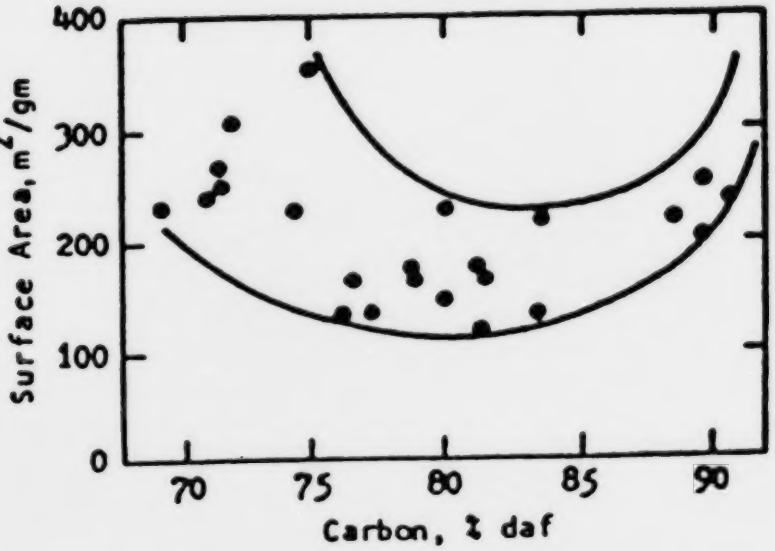

Fig. 3 The rank dependence of surface areas determined by adsorption of carbon dioxide at 25°C. (3).

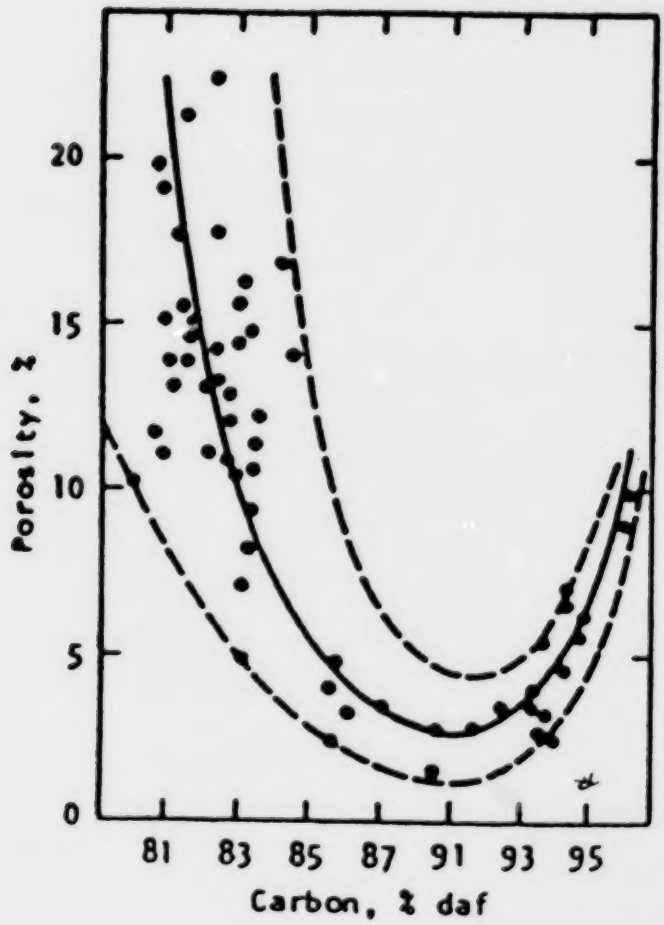

Fig. 4 The variation of coal porosity with rank. (4).

METHANE DESORPTION

* FACTORS AFFECTING DESORPTION
* RATE OF DESORPTION
* TOTAL VOLUME OF DESORPTION
* DESORPTION FROM A SEAM
* DESORPTION FROM FRAGMENTED COAL
* DESORPTION PREDICTION

METHANE DESORPTION FACTORS

INHERENT

- HARDNESS
- BRITTLENESS
- DEPTH OF SEAM
- GAS PRESSURE
- PROXIMATE ANALYSIS

EXTERNAL

- AIR PRESSURE
- AIR TEMPERATURE
- DEGREE OF FRAGMENTATION

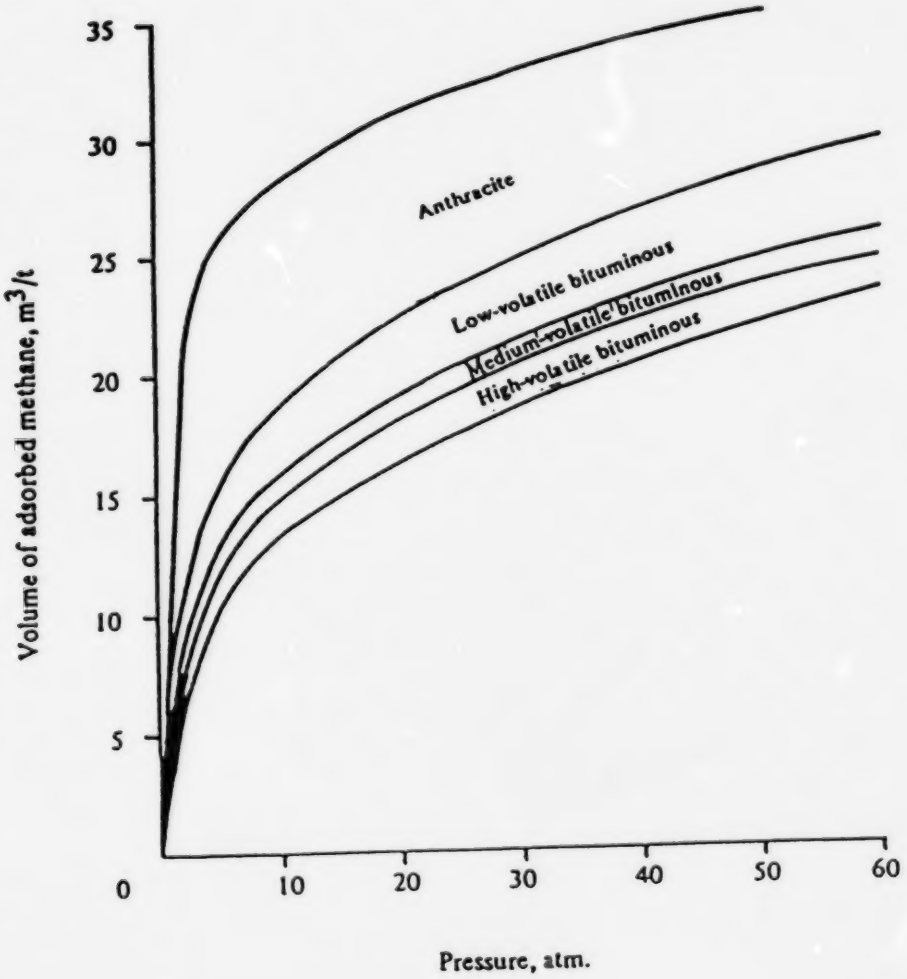

Fig. 5 Variation of methane adsorption isotherm with coal rank at 0°C. (5).

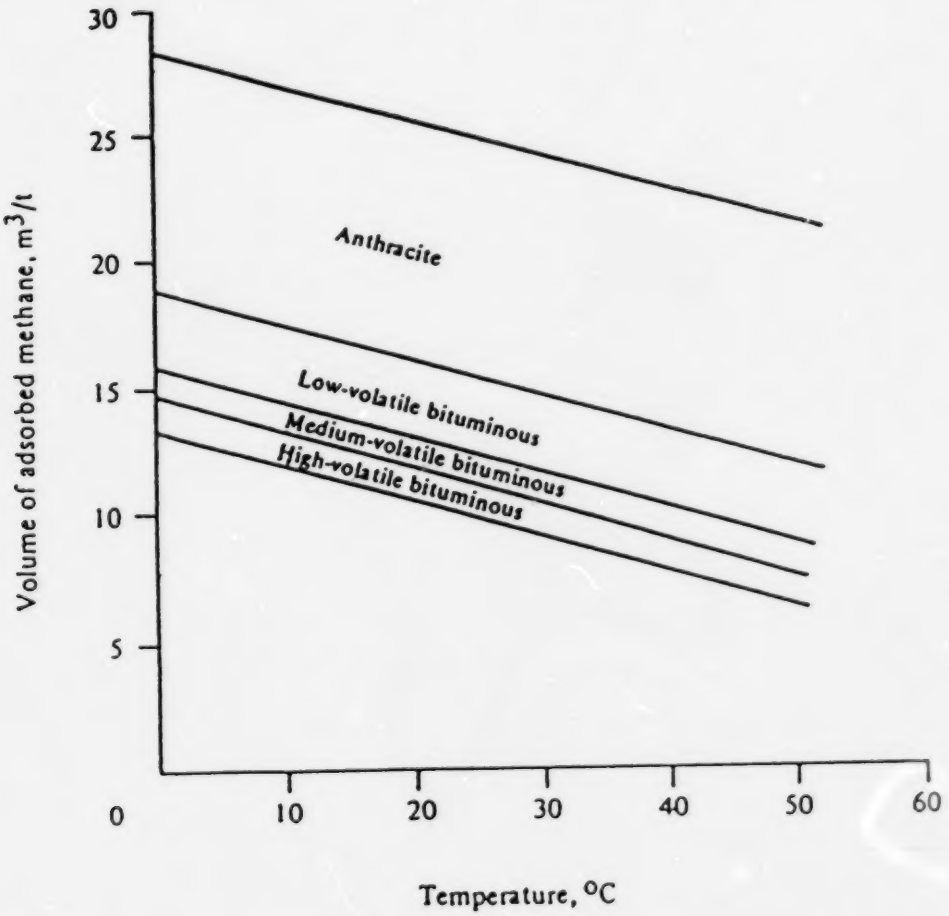

Fig. 6 Variation of coal adsorption capacity with temperature and rank at 10 atmospheres. (5).

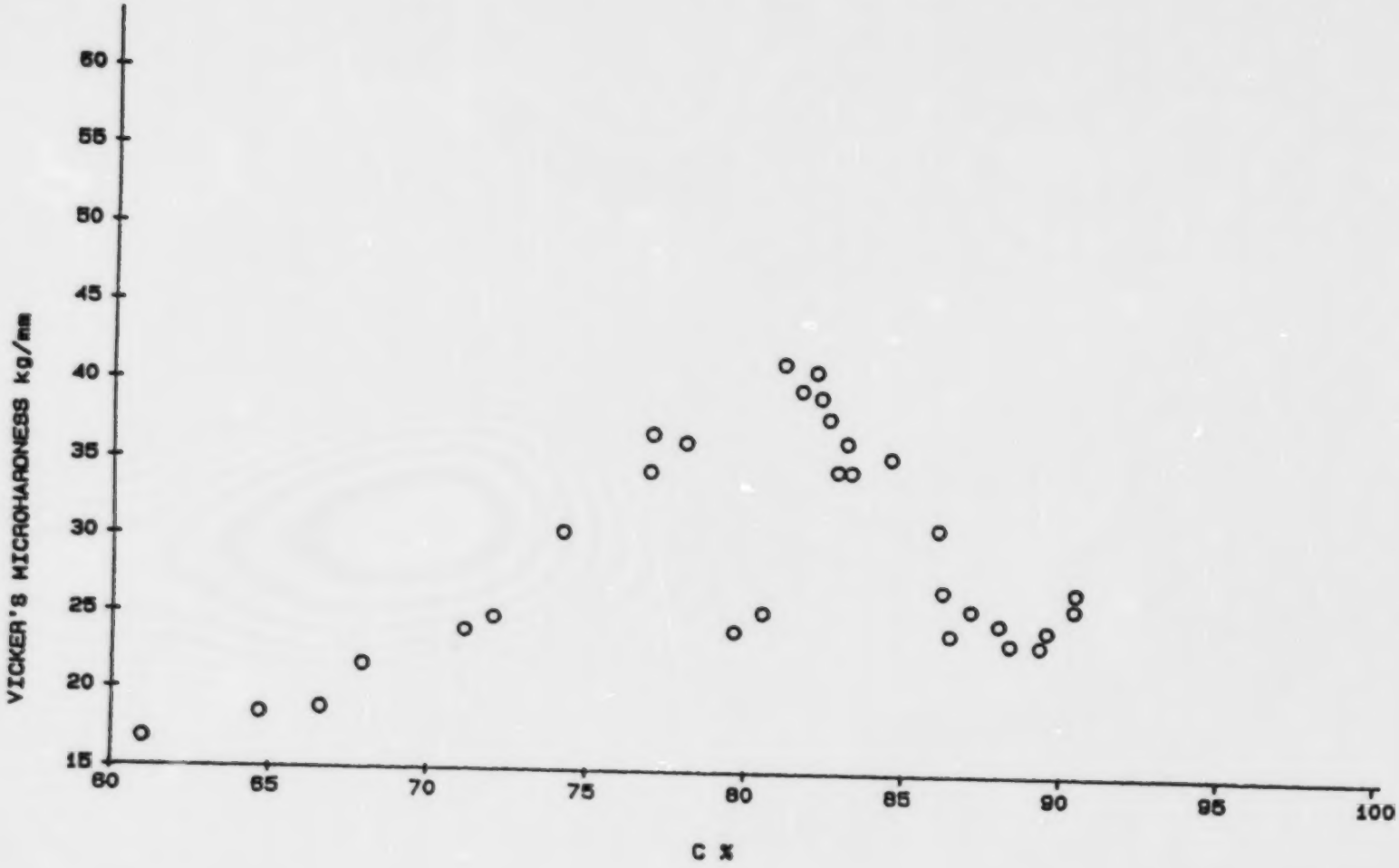

Fig. 7 Vicker's Microhardness Versus Rank of Coal. (6).

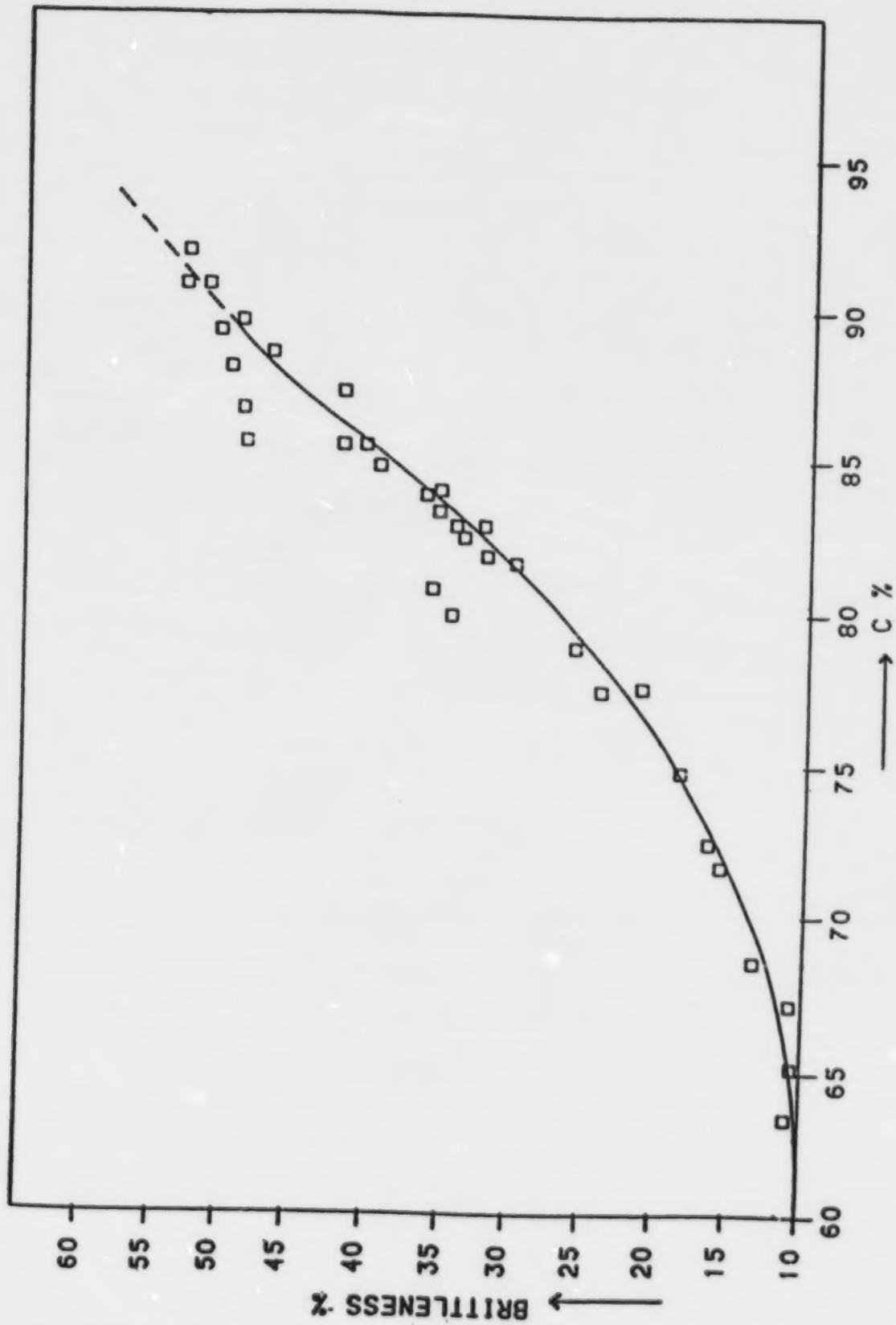

Fig. 8 Brittleness Versus Coal Rank. (6).

RATE OF DESORPTION

* VERY HIGH RATE (PRIME COKING COAL)
  * HAZARDOUS FOR UNDERGROUND MINING
  * MAY OR MAY NOT BE GOOD FOR SILOS
  * SAFER FOR COAL SHIPS

* MODERATE RATE (COKING, CAKING, ANTHRACITE)
  * HAZARDOUS FOR SILOS/PREPARATION PLANTS
  * LESS SAFE FOR COAL SHIPS

* SLOW RATE (HIGH VOLATILE BITUMINOUS)
  * SAFER FOR UNDERGROUND MINING
  * HAZARDOUS FOR LONG STORAGE AND COAL SHIPS

TOTAL VOLUME OF DESORPTION

* NORMALLY IT IS LESS IMPORTANT
  EXCEPT:

  * WHEN CONSIDERED TOGETHER
    WITH THE RATE OF DESORPTION

  * IN UNVENTILATED WORKINGS
    AND STORAGE FOR A LONG PERIOD

  * IN METHANE RECOVERY
    AS A SOURCE OF ENERGY

DESORPTION PREDICTION

* SIMPLE METHODS
    * DIRECT DESORPTION
    * MICROHARDNESS METHOD

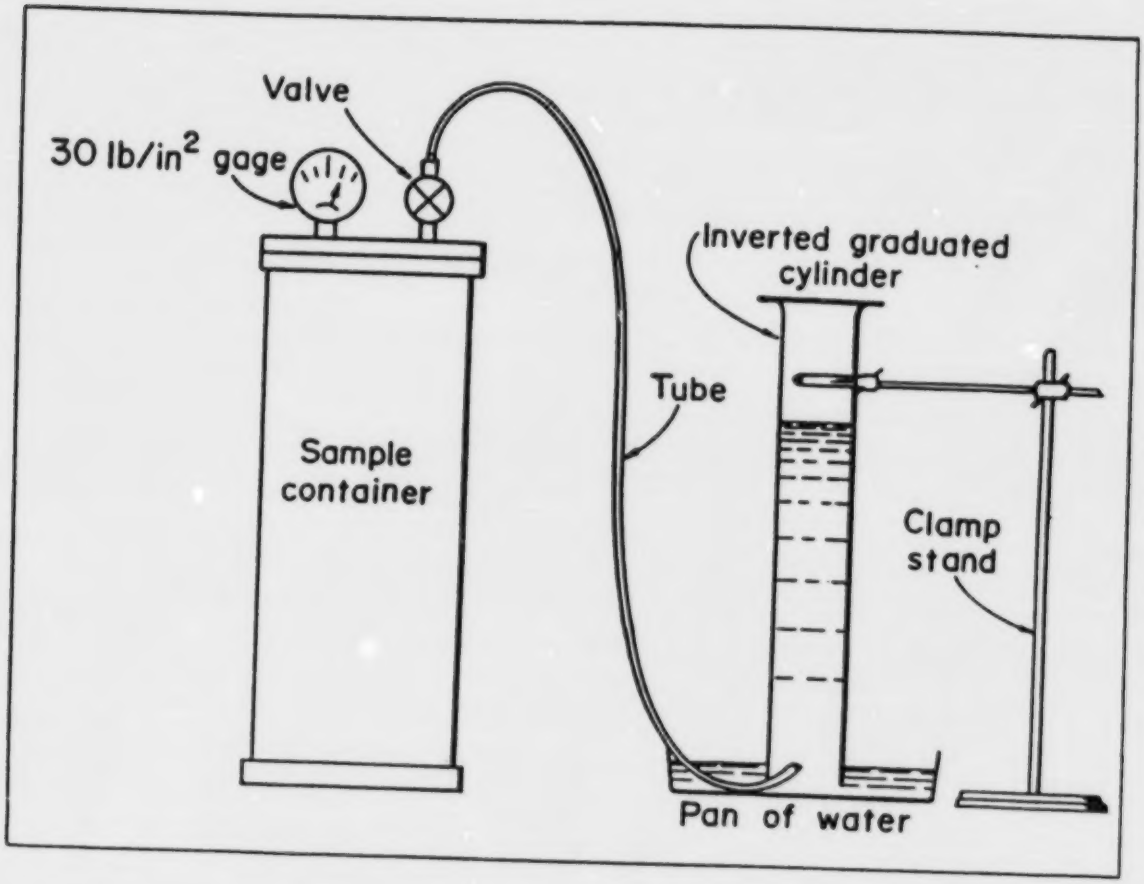

Fig. 9 Diagram of desorption apparatus (7).

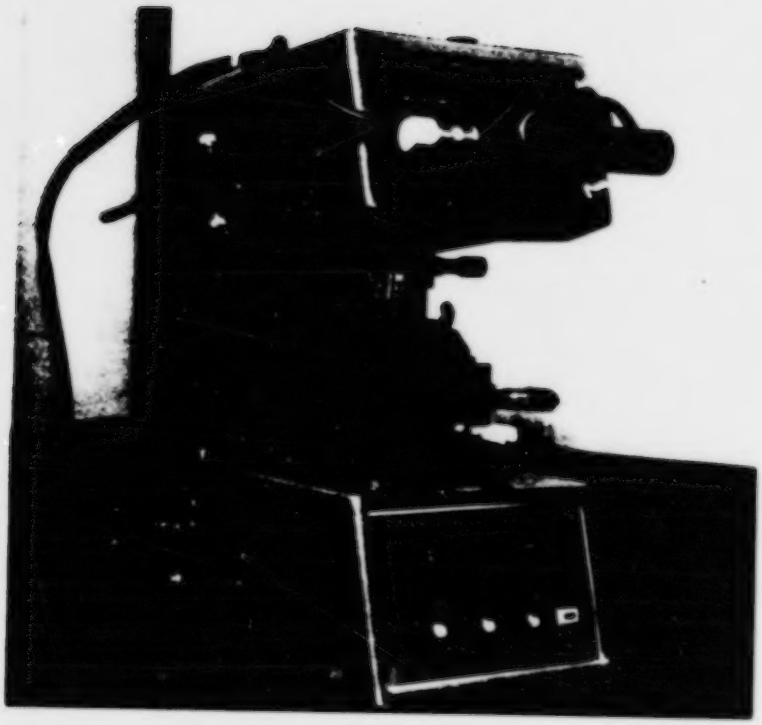

Fig. 10 Micromet Microhardness Tester.

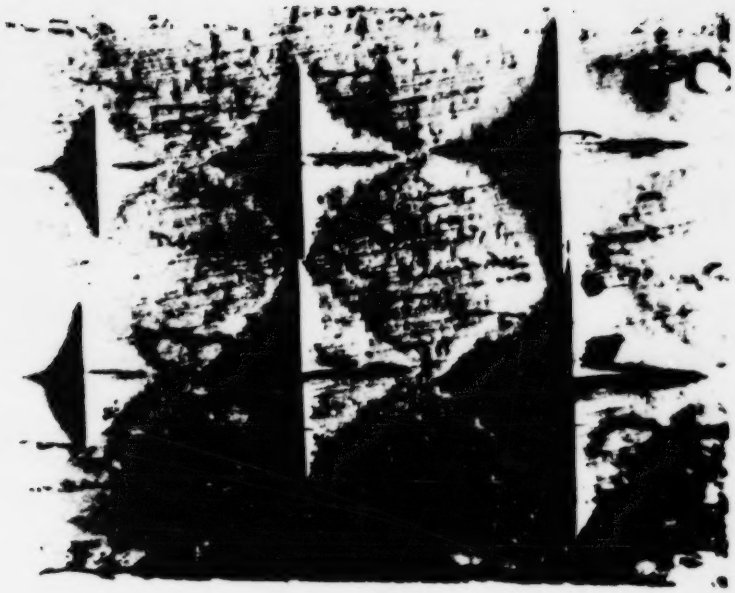

Fig. 11 Vicker's microhardness impressions (Lignite).

Fig. 12 Vicker's microhardness impressions (Medium rank sub-bituminous coal).

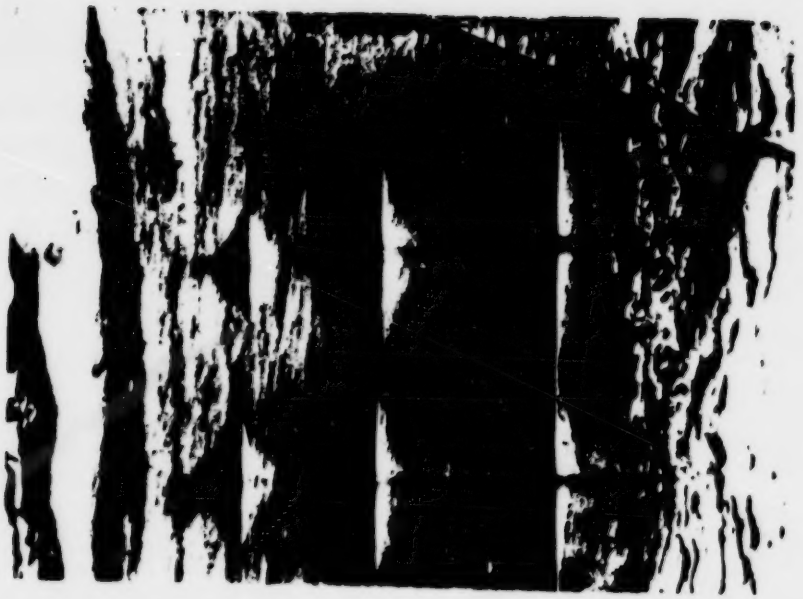

Fig. 13 Vicker's microhardness impressions (High rank bituminous coal).

Fig. 14 Vicker's microhardness impressions (Gas coal).

Fig. 15 Vicker's microhardness impressions (High volatile bituminous coal).

Fig. 16 Vicker's microhardness impressions (Prime coking coal).

COAL CLASSIFICATION FOR METHANE DESORPTION (METHANE FROM COAL PIECES)

COAL GROUP	METHANE FORMATION	METHANE RETENTION		DESORPTION CHARACTERISTICS		
		CAPACITY	ACTUAL	COAL PROPERTY INDEX	RATE	TOTAL VOLUME
LIGNITE/ SUB-BITUMINOUS COAL	VERY LOW	HIGH	VERY LOW NEGLIGIBLE	LOW	LOW	NEGLIGIBLE
HIGH VOL. BITUMINOUS COAL	LOW	MODERATE	LOW	MODERATE	LOW	LOW
CAKING/LOW COKING COAL	MODERATE	MODERATE	MODERATE	HIGH	MODERATE	MODERATE
PRIME COKING COAL	HIGH	HIGH	HIGH	EXTAMELY HIGH	EXTREMELY HIGH	HIGH
SEMI-ANTHRACITE	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	HIGH	VERY HIGH
ANTHRACITE	EXTREMELY HIGH	EXTREMELY HIGH	EXTREMELY HIGH	MODERATE	MODERATE	EXTREMELY HIGH

CONCLUSIONS

Desorption of methane from coal is the resultant effect of:

* Methane Formation
* Methane Retention
* Desorption Characteristics

Desorption characteristics of coal pieces are different from those of a seam in situ.

Desorption rate rather than desorption volume controls methane hazard.

Coal rank and maceral composition are the most important material characteristics and temperature, pressure and the degree of fragmentation are the external ones.

The following two simple methods are very useful:

* Microhardness methods
* Direct desorption method

Coal classification for methane desorption should be further studied for precision.

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